Pest Management Alliances Final Report

Agreement No. 98-0325

Development of an Integrated System for Controlling San Jose Scale, Peach Twig Borer and Oriental Fruit Moth in Clingstone Canning and Fresh Shipping Peaches, Plums and Nectarines

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ABSTRACT

The purpose of this project is to augment the California Department of Pesticide Regulation 1999 Demonstration Grant Project. The project will evaluate and implement sustainable pest management practices for San Jose Scale (SJS), Peach Twig Borer (PTB), Oriental Fruit Moth (OFM), forktailed bush katydid and Western Flower thrips in clingstone canning and fresh market peaches, plums and nectarines. Conventional use of organophosphates (OPs) and carbamates to control these pests account for approximately 80% of pesticide applications in 131,000 acres of stone fruit orchards annually. The project will develop a comprehensive pest management program to reduce or eliminate the need for the use of OPs and carbamates to control these pests. The objectives are to 1) test the efficacy of new reduced risk insecticides and oils to abate the application of OPs for either dormant or in-season control, 2) survey and identify endemic/commercial parasite strains and develop a biological control augmentation program for controlling SJS, 3) promote increased use of pheromone mating disruption for PTB and OFM through a comprehensive evaluation of recommended application rates for commercially available products, thus reducing system failure and 4) establish grower demonstration plots throughout the production region to encourage and educate growers to adopt reduced risk practices for controlling SJS, PTB, OFM and thrips.

The Food Quality and Protection Act (FQPA) may have a serious impact on stone fruit production through the loss of commonly used OPs and carbamates which are used to control SJS, PTB OFM and thrips. Current dormant spray use patterns and in-season application of OPs may contribute to the decline in the quality of surface and ground water. In addition, increasing evidence suggests SJS is resistant to materials traditionally used for multiple arthropod species control. Therefore, this project seeks to mitigate the risks of routine OP use through the development of a model integrated system for implementation in canning and fresh market peach, plum and nectarine orchards throughout California.

EXECUTIVE SUMMARY

The objective of this ongoing project is to develop an integrated and sustainable pest management program for peaches, plums, and nectarines in California. The research has focused on San Jose Scale (SJS), Peach Twig Borer (PTB), Oriental Fruit Moth (OFM), Omnivorous Leafroller (OLR), katydids and thrips. All elements of the Pest Management Alliance grant activities have been presented at grower and PCA demonstration plots and meetings. In addition, information developed as a part of this research effort was disseminated through grower newsletters and via pest management and commodity websites.

Stonefruit production has traditionally relied upon organophosphate and carbamate insecticides to control the majority of pests. Due to environmental and human health concerns, a movement away from these types of materials has been initiated. The testing of commercially available oils, pheromone dispenser systems, and reduced risk pesticides in controlled research situations has provided the basis for the development of best management practices for utilizing more integrated pest management approaches. In addition, the evaluation and development of an augmentative biological control program may increase SJS, PTB, OFM and thrips parasitism levels and further reduce the need for insecticide applications.

During the first year of a projected 3 year project, substantial progress towards meeting the objectives has been made. (It should be noted that the timeframe for this project, June 99 to June 00, is not synchronized with the harvest, thus many of the results reported are from the first year in the lab. Some preliminary results from implementation in the demonstration blocks, if known at this early date in the harvest, may be discussed.) First, efficacy trials of two commercially available oils as the single component in a dormant spray for controlling SJS have been completed. The results suggest that both oil formulations may abate overwintering populations of SJS under low to moderately infested conditions. Second, a preliminary survey of endemic and commercially reared natural enemies of SJS has been accomplished. Insectary rearing of potential parasitoids for augmentative release and field testing is underway. Third, field comparisons and aging studies of commercially available PTB and OFM pheromone formulations and dispensers have yielded data to further refine application rates. Fourth, several reduced risk chemicals show potential to be an alternative to the industry standard, Carzol, for thrips control. The information will be used to develop practical recommendations designed to reduce grower uncertainty and potential failure when utilizing this technology. Finally, industry education and information dissemination is ongoing through industry sponsored newsletters, website postings and educational events.

Report

A. Introduction

The foremost proportion of OPs and carbamates applied to clingstone canning and fresh market peach, plum and nectarine acreage in California is to control SJS, PTB and OFM. This accounts for the use of these materials on 131,000 acres under stone fruit production from Tehama to San Bernadino counties. In a survey of growers conducted by the California Tree Fruit Agreement (CTFA), 50% of those who responded stated they had had some difficulty controlling SJS in the past. Further, 13% of the respondents stated they had removed orchards due to the inability to control SJS. Based on previous scientific evidence, SJS is exhibiting resistance to OPs and carbamates placing growers in a cycle of increasing material usage with declining pest control returns. In addition, technical challenges in using pheromone mating disruption for PTB and OFM have resulted in growers experiencing unacceptable fruit damage and has resulted in the return to the traditional use of OPs and carbamates. Accordingly, future strategies must reduce the exposure of SJS to OPs and carbamates. Management of other primary pests (PTB and OFM) will also rely on less exposure to OP's and carbamates..

Therefore, the scope and the purpose of the project is to take a statewide approach, through the combined efforts of the California Tree Fruit Agreement (CTFA) and the California Cling Peach Growers Advisory Board (CCPGAB). It is intended to advance the benefits of a coordinated comprehensive SJS, PTB and OFM research effort, with no one area of the research promising complete solutions to the problems currently being experienced by the stone fruit industry. This is being accomplished through the development of a system where the combination of replacing OPs with oil, pheromone mating disruption, reduced risk chemicals and developing a system for orchard augmentation with natural enemies will maintain SJS, PTB and OFM populations below an economic injury level. It should be noted that the timeframe for this project, June 99 to June 00, is not synchronized with the harvest, thus many of the results reported are from the first year in the lab. Some preliminary results from implementation in the demonstration blocks, if known at this early date in the harvest, may be discussed.

The attainment of the multiple pest management system, where OP and carbamate use is reduced or eliminated, is designed to curtail the potential for pest outbreaks, conserve endemic and augmented natural enemies, increase grower confidence in the efficacy of alternative materials such as oils, pheromone mating disruption, and new reduced risk chemicals, and sustain the economic viability of production costs over time. Moreover, the project is intended to help mitigate environmental impacts from the use of OPs and carbamates by reducing the influx of runoff into above and below ground water systems through decreased use of these two classes of chemicals.

B. Materials and Methods

1. <u>Examine the efficacy of commercially available oils for controlling SJS</u>. Walt Bentley, UC IPM Entomologist, was responsible for this portion of the project. The specific tasks were: a) apply oils as dilute dormant sprays (commercially available) and compare the treatments to an untreated check; b) trials would be replicated in a RCB design for statistical analysis and fruit samples taken to calculate percent scale infestation and c) crawlers and adult males would be sampled with sticky tape for comparison to fruit data, and to evaluate efficacy of the treatments over time.

Two commercially available oils, Orchex 692 and Volck Supreme, were applied as dilute dormant spray to evaluate the impact of oil sprays on varying population densities of SJS. Both oils were applied at the rate of 8 gallons of oil in 400 gallons of water per acre in late January 1999 with an Air-O-Fan sprayer. The design was a split plot, randomized complete block with 3 replicates of 3 differing population densities of SJS and the plots were 13 trees long and 4 rows wide. The consistent factor of each treatment was the oil at 8 gallons per acre with the variable factor the scale population density. All work was carried out in a block of plums at the Kearney Agricultural Center in Parlier. This block has a history of SJS populations ranging from moderate to high and has been used for insect growth regulator efficacy trials for controlling SJS. An untreated check treatment was included.

During the spring (April 1999) randomly selected limbs in each of the subplots were equipped with either a double sided sticky tape or pheromone traps to begin monitoring for both crawlers and adult males. Tapes were routinely collected and counted for crawler activity while traps were examined for adult males and parasitoids. At harvest, 500 fruit from each subplot were examined for scale infestation and results were recorded. The results were tested using the sum of squares and Fisher's protected LSD.

2. Describe the natural enemy complex attacking SJS in stone fruits and determine the potential to manipulate one or more of these natural enemy species. Dr. Kent Daane, UC Biological Control Entomologist, was responsible for this portion of the project. The tasks included a) survey stone fruit orchards with and without SJS scale infestations to determine if resident natural enemies have potential to control pest densities, b) establish insectary colonies of the more common and effective resident SJS parasitoids, c) determine the effect of commonly used insecticides on selected natural enemies and d) in laboratory trials, test the effectiveness of commercially available SJS parasitoids.

Surveys of commercially producing stone fruit orchards, with and without a history of economically damaging SJS population densities and varying pest management strategies from organic to OP/carbamate use, were accomplished to determine the resident natural enemies. Beginning in mid May 1999, orchards were sampled weekly throughout the season. SJS were collected from tree/fruit and SJS infested butternut squash were hung in trees as parasitoid traps. Samples were taken to the laboratory where scale life stage and number were recorded. The collected material was then placed into emergence containers where parasitoids were reared and subsequently identified to species (Mike Rose, a taxonomy expert of hard scales, performed this portion of the project). In addition, data collection was completed and the percentage parasitism and density of parasites for each orchard was calculated.

3. Begin field comparisons of commercially/experimentally available PTB and OFM pheromone formulations and dispensers and develop practical recommendations for use by growers. Jeanine Hasey, UCCE Farm Advisor for Yuba and Sutter counties, was responsible for this portion of the project. The specific task for this portion of the project was to follow the standard protocol used by universities for evaluating mating disruption.

A 42 acre block of Halfords in Yuba County with a history of low populations of OFM and PTB was divided into six - seven acre blocks. The treatments were as follows:

- Grower Standard - sprayed 3 times with OP
- Unsprayed check
- Check - received a single OP spray
- Isomate M-Rosso (for OFM); Isomate PTwB (for PTB)
- Isomate M-100 (for OFM); Confuse-PTB (paraffin emulsion sprayable)
- Consep Checkmate OFM; Consep checkmate PTB
- Confuse OFM (paraffin emulsion sprayable); Confuse-PTB (paraffin emulsion sprayable)
- Consep OFM-Flowable; Checkmate PTB

The OFM biofix was February 24, 1999. OFM pheromone products were applied on February 26, except Confuse-OFM which was applied on March 4. The OFM-Flowable product was applied every 28 days throughout the season for a total of 7 spray applications. PTB pheromone products were applied on May 5th and 6th, 1999, preceding PTB biofix. Concurrent with application, all pheromone products were placed in another peach block far away to be collected at certain intervals for release rate testing (aging study).

Traps were monitored weekly. The north and south outside tree and center 10 trees in the middle of each plot were monitored for shoot strikes weekly starting in mid May. Fruit was inspected weekly in the check trees for green fruit strikes starting mid July. Fruit was again inspected for damage at harvest on August 26th and 30th.

4. Begin reduced risk material efficacy trials for controlling thrips under controlled research plot conditions. Richard Coviello, Walt Bentley, Richard Rice, and Kevin Day were responsible for this project. A randomized complete block field trial with three replications was conducted at the Kearney Agricultural Center to evaluate alternative compounds, particularly reduced risk compounds for controlling western flower thrips (*Frankliniella occidentalis*). Materials evaluated included: Agri-mek, Esteem, and Success as compared to the standard, Carzol. An untreated check plot was included for comparison. Treatments were applied by high pressure handgun at 225 GPA equivalent. Treatments were evaluated by examining fruit for thrips scarring at thinning and at harvest. The effect of the treatments on SJS was evaluated by the use of double sided sticky tape to sample crawlers and by examining the fruit at harvest for scale presence at harvest.

5. Implement a minimum of 4 grower demonstration plots, one each in Tulare, Fresno, Kings, and Yuba/Sutter counties. Research coordinators for CTFA and CCPGAB, along with those team members representing cooperative extension, were to coordinate and establish industry volunteers to provide orchard blocks of 5 to 10 acres on which to carry out the research of reduced risk management practices in commercial orchards.

6. Enhance communication and implement grower information dissemination. Gary Van Sickle, CTFA, and Heidi Sanders, CCPGAB, were responsible for this portion of the project. Specific tasks included a) provide quarterly updates to clingstone canning and fresh market peach, nectarine and plum growers of project progress through newsletters. The information was also posted on the industry websites; b) Coordinate 3 field days with University of California in June, July and August so researchers may communicate directly with growers at the actual research site and 3) provide an annual report of research progress both through the CTFA Research Report and at the Winter Tree Fruit day research symposium held in December.

C. Results

1. Examine the efficacy of commercially available oils for controlling SJS. The specific tasks for this portion of the project were met. Data collected from traps and fruit infestation seem to indicate both Orchex 692 and Volck Supreme oils were effective in managing viable populations of SJS when applied in a dilute dormant application. Both treatments showed a significant difference in the number of fruit infested with SJS at the time of harvest when compared to the untreated check.

Plums harvested in July of 1999 and treated with either Volck Supreme oil or Orchex 692 oil were found to have acceptable levels of San Jose Scale infestation. Given the parameters of treatment in 1999, these two refined horticultural oils could be used to manage SJS infestation and delay the use of other insecticides to which SJS is known to have developed insecticide resistance.

The results of a second test where plums were harvested in August also showed successful control of SJS where infestation was measured to be lowest in 1998. These lower infestations of SJS in 1998 were found in the Esteem and Applaud treated plots. Although greater SJS infestation was found in the 1998 Diazinon treated and oil alone plots, infestation levels were still acceptable. Either of the refined mineral oils used in this trial could be used in the future, given the parameters of the 1999 application, that being where SJS abundance is low. Where scale abundance is high, as measured by the previous year's infestation, the use of mineral oils may not provide acceptable control. In the future Esteem might be used to knock down the SJS population, then treatment with oils should suffice.

The use of double-sided sticky tapes was not as consistent a measurement as was scale infestation. However the sticky traps did describe the trends of infestation based on the number of crawlers found on them.

In addition to the substantial control of SJS in the reduced risks blocks, there were significantly more parasitoids in these blocks, as compared with the parasitoid counts in the conventional blocks. The difference is attributable to the use of organophosphates and pyrethroids in the dormant oil application of the conventional blocks.

More *Encarsia* were observed on SJS traps than *Aphytis*, and the data provides a possible explanation for this important phenomenon. *Encarsia* emerged in the largest numbers by early-April, while *Aphytis* emerged in late-April. Female SJS reach sexual maturity (approximately 500 DD accumulated) soon after the males (400 DD), and the females then begin releasing pheromones to attract males. The timing of this event corresponds closely with the emergence of *Encarsia*, but not that of *Aphytis*. It may be that *Aphytis* simply are not attracted to the pheromone because they do not typically emerge when the females are using pheromones. Having staggered emergences may be allowing the parasitoids to avoid direct competition, and thereby more effectively controlling the SJS. The very high parasitoid counts are a strong indication that the parasitoids are helping to suppress scale populations.

To verify these preliminary results, the objective will be repeated in 2000.

2. <u>Describe the natural enemy complex attacking SJS in stone fruit and determine the potential to manipulate one or more of these natural enemy species</u>.

Three parasitoid species were found to dominate the natural enemy complex in the orchards: *Encarsia perniciosus, Aphytis aonidiae, and Aphytis vandenboschi*. *Encarsia perniciosi* was found in every orchard sampled, *Aphytis* species in general were less common in the orchard and on SJS pheromone traps as compared to *Encarsia*. In most orchards SJS was not an economic problem, in large part due to the action of natural enemies.

Insectary colonies of SJS and parasitoids were established. The SJS scale were reared using a methodology similar to that used by Dr. Dick Rice, UC Entomologist, with the exception smaller sized butternut squash hosts were used to better manipulate SJS in laboratory studies. Crawler stage SJS were sprinkled onto the butternut squash substrate where the crawlers then insert their mouthparts, settle to feed and complete their life stages. The number of live scale per square inch in a grid for each inoculated squash was documented. The SJS squash was then used to sustain the scale and provide for live host material to test the parsitizing capabilities of commercially available parasitoids. In particular, *Aphytis melinus* was chosen for this portion of the project. Percent parasitism and scale mortality were calculated after exposing the female parasitoids to the scale infested squash for 3 days. Parasitoid fecundity was determined after 3 to 4 weeks by counting the F_1 progeny. This study is ongoing and results from the bioassays will be available at a later date.

Finally, orchards with low to moderate population densities of SJS were identified and release of commercially available parasitoids begun. Two plots were established in early September 1999. Parasitoids were released at the center point of each plot. Transects moving from the release points were established. The population of SJS and the effectiveness of the released parasitoids were sampled along the transects using the SJS infested butternut squash traps. Samples of SJS were collected and brought to the laboratory to rear out parasitoids and calculate percentage parasitism and scale mortality.

As a result of the orchard surveys, two groups of endemic parasitoids (*Encarsia* and *Aphytis* spp.) have been considered to provide biological control for SJS. Of the two parasitoid groups, a species of *Aphytis* (*A. melinus*) is currently commercially reared as part of an inundative biological control augmentation program for regulating populations of California Red and Yellow Scale in citrus, which are closely related to SJS. While *A. melinus* was not specifically reared from field collected SJS, it was decided to test this species as a potential biological control agent because the parasitoids are affordable and generally obtainable on demand. The expense of establishing a new species of commercially reared parasitoid is cost prohibitive and not likely to occur. Therefore, this species of *Aphytis* was chosen for laboratory screening to determine if augmentative release for controlling SJS is feasible. Preliminary laboratory results indicate *A. melinus* will both parasitize and cause physical injury to SJS. Subsequently, *A. melinus* caused mortality to SJS reared on butternut squash. However, more work is needed to determine if the parasitoid will perform as well under field conditions with the ability to search for preferred host material.

Currently, field tests are on-going to test the effect of released parasitoids. Using commercial *A. melinus* material, natural enemies have been released at a center point in established plots, and parasitoid activity is being monitored in transects moving from the release points. Preliminary data charts from spring activity (Figures 1 - 7) show a "textbook" relationship for the *Encarsia perniciosi* and *Aphytis* population activity compared to the SJS population.

3. <u>Begin field comparisons of commercially/experimentally available PTB and OFM pheromone formulations and dispensers and develop practical recommendations for use by growers.</u> Throughout the season, both OFM and PTB trap catches were low in the check and grower standard. The OFM population did not build as was expected and dropped off during the summer in the check and grower standard. The various pheromone treatments suppressed OFM trap catches except in the flowable treatment. Moths were caught 28 days after the application in March, April, and May indicating there was no longer enough pheromone in the flowable treatment to suppress trap catches. The PTB pressure was extremely low. The pheromone treatments suppressed PTB trap catches, except at the end of August in one of the paraffin emulsion blocks.

There were very few shoot strikes throughout the season across the plots, well below the 3 – 5 per tree signaling the need for a spray treatment. There was extremely low worm damage in the OFM flowable, paraffin emulsion, Checkmate OFM and untreated check and no damage in the Isomate and grower standard treatments. The explanation for the lack of damage in the check could have been from pheromone influence due to a very windy season or to low OFM and PTB populations.

The application costs of the various pheromone treatments were compared. In general, the costs were less for the second application, except for the M-Rosso which remained the same. As the workers became more experienced, the dispensers were applied more quickly. Labor costs were least for the OFM flowable applied by a spray rig and the paraffin emulsion applied from the ground with a forestry paint marker gun.

In the pheromone aging study, release rates were closely correlated to temperatures. This trend was observed with most products for both OFM and PTB. Additionally, most of the pheromone was released during the first month of the study. The results of the aging study were inconclusive with regards to residual pheromone and mating disruption due to a low worm population and a lack of efficacy data.

Results on aged dispensers or material is preliminary. Confuse-OFM continued to release active ingredient over 116 days. Isomate M-Rosso lasted 130 days. The aging methodology for the OFM-Flowable material is experimental. Preliminary data for March – June, 2000, is not yet available.

4. Begin reduced risk material efficacy trials for controlling thrips under controlled research plot conditions. All materials tested reduced the percentage of petal fall thrips scarring below the untreated check, including Esteem. There were no significant differences between materials, but both Success and Agri-Mek were numerically better than the standard Carzol. San Jose scale infestations, which were treated at bloom to check for efficacy based on an application at this time period, were reduced in the Esteem plots, but this was not significantly less than in the Carzol plots. The total number of SJS crawlers collected on double sided sticky tape during the season was not statistically different among treatments, however, the total number in the Esteem plots were far below that in other treatments. A high level of variation within the experiment accounted for the lack of statistical significance.

The results of this trial show potential alternatives to Carzol. Agri-Mek is not registered on stone fruit at this time but does have registration on pome fruits. Success was recently registered on stone fruits, however, thrips were not listed as a labeled pest. Both of these products should be able to overcome registration obstacles should their value be demonstrated in trials conducted in 2000.

During the spring of 2000 the 1999 trial was repeated. The treatments were the same, but the orchard plots were re-randomized. The fruit will be harvested in late June. After harvest the fruit will be evaluated for thrips injury. Two other experiments are being conducted with Success. The first will develop information on application timing during the bloom. The other will look at preharvest applications applied shortly before bloom. These treatments will be evaluated after fruit harvest, which will be in late June and early July.

5. Implement a minimum of 4 grower demonstration plots, one each in Tulare, Fresno, Kings, and Yuba/Sutter counties. Research coordinators for CTFA and CCPGAB, along with those team members representing cooperative extension, coordinated with industry volunteers to establish and provide commercial orchard blocks of 5 to 10 acres on which the research of reduced risk management practices could be conducted. Unfortunately only 3 cooperators agreed to allow the reduced risks practices to be conducted in their orchards. One demonstration orchard was located in each of Kings, Fresno and Yuba counties. Plans call for expansion of the number of orchards used in the project during the second year of the project.

6. Enhance communication and implement grower information dissemination. Regular field days, coordinated by University of California and publicized by CTFA, were held on a monthly basis throughout the summer, in both 1999 and 2000. In late 1999 a Pest Management Update meeting was conducted on November 9, and the annual Winter Tree Fruit day was held on December 1. A Stone Fruit Pest Management Field Day was conducted on April 13, 2000 at the demonstration block in Kings County with approximately 75 growers and PCA's in attendance. A second event was conducted at the Yuba County demonstration block a week later on April 20 for cling peach growers. Plans are underway for another Yuba county event on June 30 and in Fresno County on July 13. Quarterly newsletters were sent to over 2000 growers, shippers, packers and other interested parties associated with the clingstone canning and fresh market stone fruit industries discussing project progress. These newsletters were also posted on industry websites. CTFA's annual Research Report and CCPGAB's annual Research Report were made available to the Industry in April 2000.

D. Discussion

Technical challenges, including increasing evidence SJS is resistant to OPs, growers experiencing unacceptable fruit damage using pheromone mating disruption for PTB and OFM and grower concerns of economic loss during the transition of instituting reduced risk practices, have been barriers to developing a comprehensive integrated pest management program for clingstone canning and fresh shipping peaches, plums and nectarines. The testing of commercially available oils, pheromone dispenser systems and reduced risk pesticides in a controlled research environment has provided a representation of best management practices for utilizing a more integrated pest management approach. Furthermore, developing a biological control program of augmentation of natural enemies may increase SJS, PTB and OFM parasitism levels and further reduce the need for OP/carbamate applications.

Overall, the objectives and tasks for the first year of the project were met. An analysis of the data indicates SJS, PTB and OFM populations may be maintained below an economic injury level in stone fruit without or with minimal use of OPs and carbamates. Thus, 3 grower demonstration plots were established in December 1999, which incorporated the reduced risk practices outlined in this project. The implementation of the demonstration blocks is aimed at addressing the dynamic pest management pressures in a commercial setting from dormant sprays to beyond harvest. The successful performance of the combination of replacing OPs with oil, pheromone mating disruption and augmenting with natural enemies under conditions and acreages growers face every day should increase grower confidence in the efficacy of alternative materials and reduced risk practices.

Some preliminary economic comparisons regarding the insecticide costs for each variety in the Fresno County and Kings County blocks are now available. (See Tables 1 - 5) There are significant differences relative to each variety, primarily related to when the variety is harvested. But a comparison of average PMA insecticide applications relative to conventional costs produces a closer comparison: \$128 per acre for the PMA blocks, and \$130 per acre for the conventional blocks. (Table 5) If these costs can remain comparable in the future, more and more growers will be willing to try the reduced risk IPM approach.

E. Summary and Conclusions

This was the first year of a comprehensive pest management project where a systems approach was taken to examine commercial orchard blocks employing reduced risk alternatives for controlling SJS, PTB and OFM in clingstone and fresh market peaches, plums and nectarines. The objectives of the project distinctly seek to substantially reduce reliance on OPs/carbamates and provide a model sustainable pest management system for stone fruit growers throughout the state of California.

The project tested the efficacy of two commercially available oils as the single component in a dormant spray for controlling SJS and found moderate populations of scale could be reduced under dilute application conditions. Work was also started to develop a biologically and economically viable inundative release program for natural enemies of SJS. Commercial orchards were surveyed and endemic natural enemies of SJS were identified. As a result, two potential groups of parasitoids, *Encarsia* and *Aphytis spp.*, were targeted as potential SJS augmentative biological control agents.

Conservation of the endemic parasitoids appears to be an immediate benefit of the oil-only dormant application, as demonstrated in 1999 and again this year. Because scale counts in the PMA blocks and standard blocks had equalized by the mid-season (after a generation of parasitoids), the value of the parasitoid activity may be equated with the cost of dormant-applied organophosphates and pyrethroids.

To date, testing has begun with an easily attainable commercially produced parasitoid, *Aphytis melinus*. As indicated earlier, Figures 1 – 7 illustrate a positive parasitic relationship in that when the SJS population increased, the *Encarsia* and *Aphtyis* populations also increased. Conversely, when the SJS population dropped the parasitoid population also declined.

Moreover, work was completed to evaluate the efficacy of experimental and commercially available pheromone mating disruption dispensers and formulations for controlling larvae damage from OFM and PTB. The efficacy results were inconclusive due to low populations of both OFM and PTB in the research block. Consequently, a comparison between percent of fruit damage in the untreated check and between the treatments could not be made. However, preliminary information was obtained during the aging studies of the pheromone dispensers which will be used to develop a refined application rate. Progress was also made in regards to thrips control. Two potential alternatives, Success and Agri-Mek, could provide satisfactory control compared to the industry standard Carzol. Several commercial orchard blocks were utilized to demonstrate reduced risk practices compared to conventional practices. The number of sites needs to be expanded next season. Of great interest is the preliminary information that costs for reduced risk practices may be comparable to conventional costs. If fruit damage is similar for the two practices there should be greater grower acceptance to implementing reduced risk pest management practices. Finally, the CTFA and CCPGAB utilized their communications infrastructures to support UC grower education events, published quarterly newsletters and maintained active websites. It is now hoped that more growers will continue the transition towards a reduced risk pest management program for California stonefruit.

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Appendix

Figure 1.

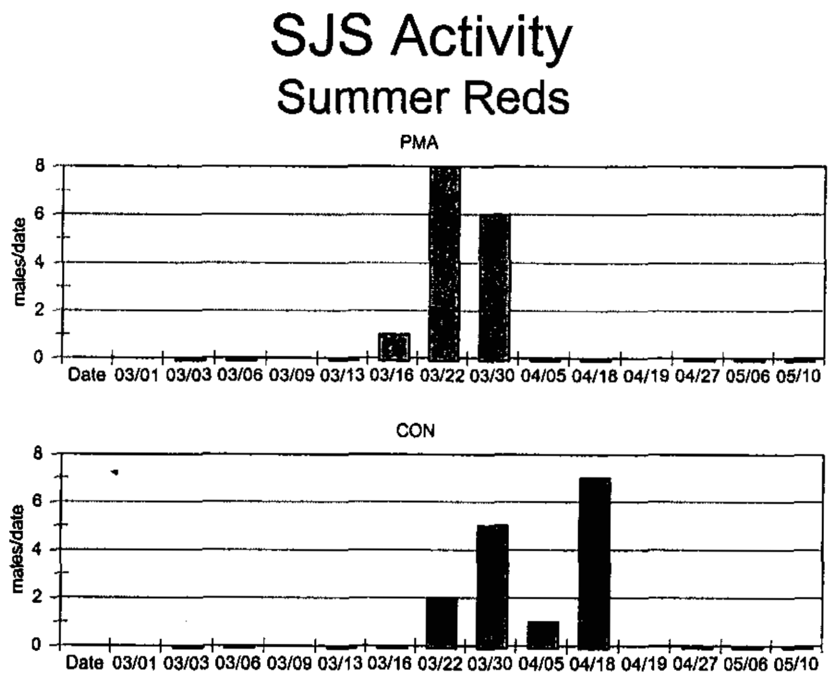


Figure 2.

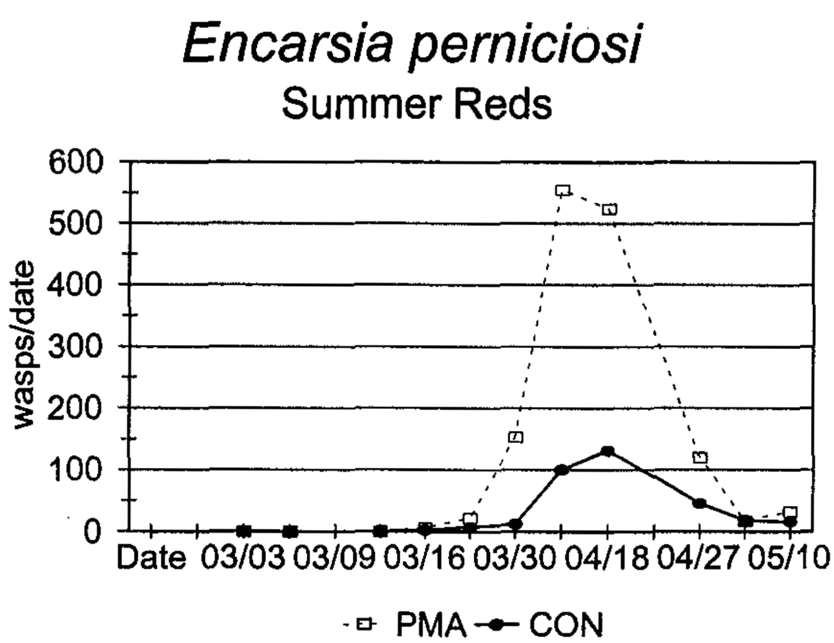


Figure 3.

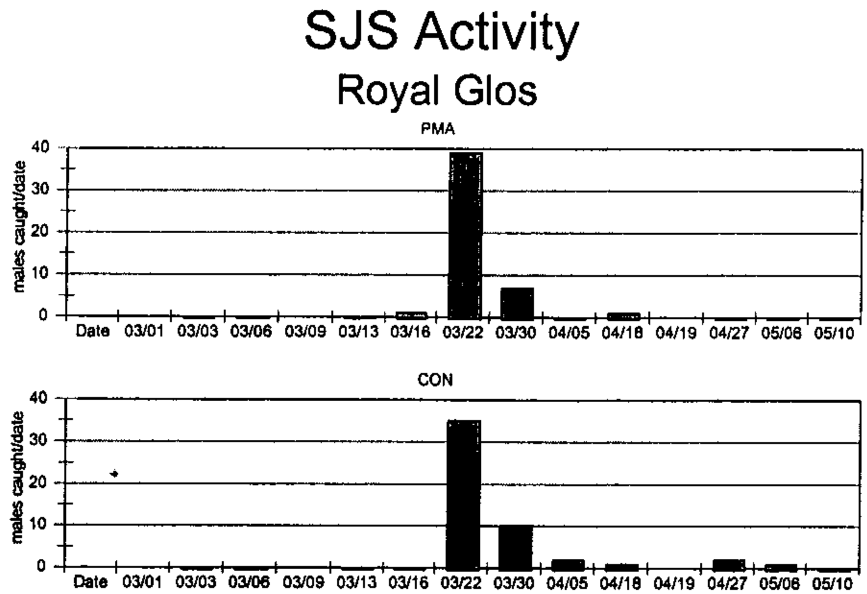


Figure 4.

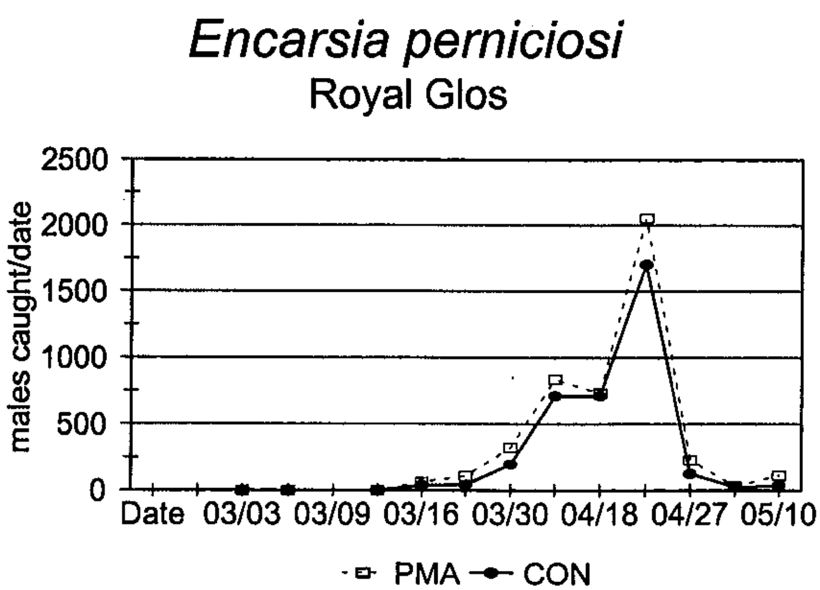


Figure 5.

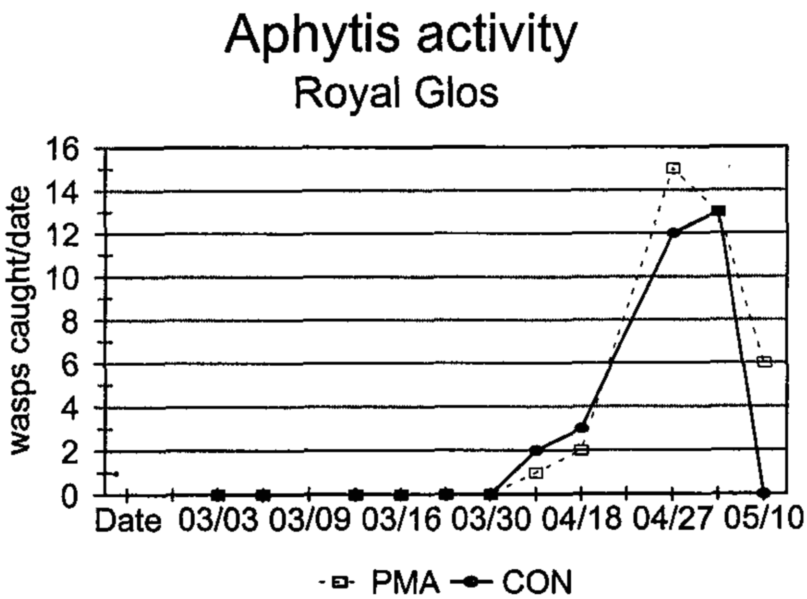


Figure 6.

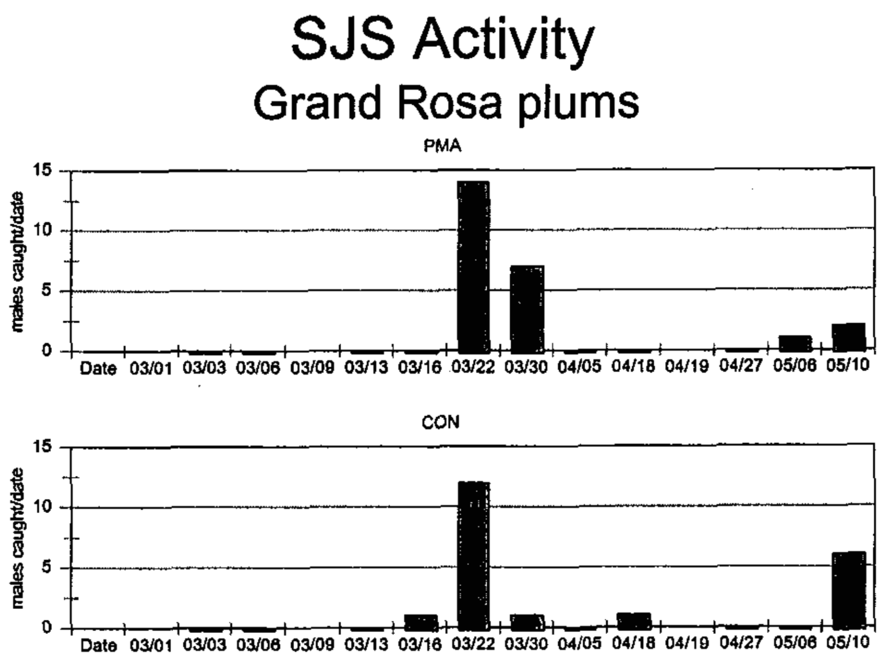
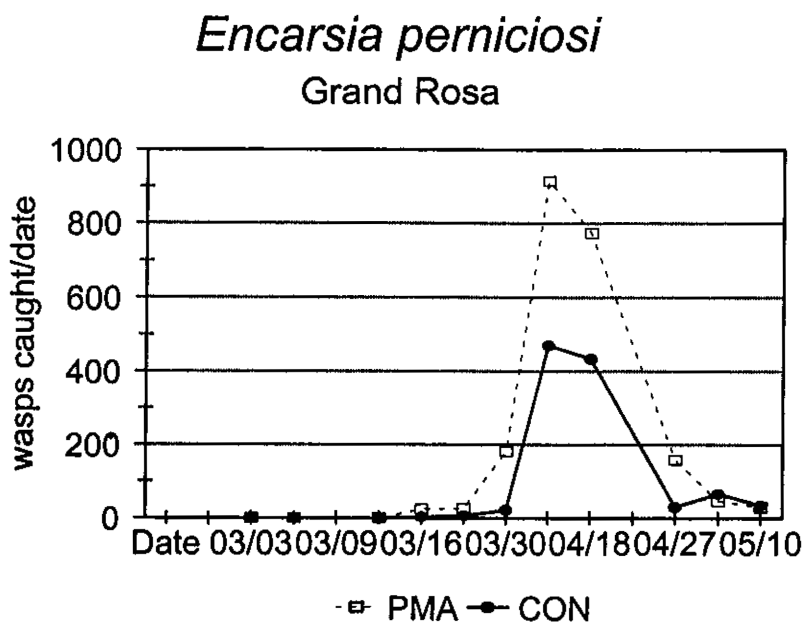


Figure 7.


Encarsia perniciosi
Grand Rosa
wasps caught/date
1000
800
600
400
200
0
Date 03/03 03/09 03/16 03/30 04/18 04/27 05/10
PMA
CON

Stone Fruit PMA Economic Analysis
Insecticide and Miticide Applications

Table 1.

Elegant Lady Peaches

	PMA block				*Standard block*			
Stage	product	date	rate/acre	cost/acre	product	date	rate	cost/acre
DORMANT	Hort. Oil	01/29/00	6 gal.	$18	Hort. Oil	01/29/00	3 gal.	$9
					Asana	01/29/00	8 oz.	$16
					Lorsban 4E	01/29/00	2 qt.	$20
Subtotal				***$18***				***$45***
BLOOM								
subtotal				***$18***				***$45***
PETAL-FALL	Isomate ties	late-Mar	100 ties	$35				
subtotal				***$53***				***$45***
IN-SEASON	Success	05/21/00		$29	Success	05/21/00		$29
subtotal				***$82***				***$74***

Table 2.

Summer Red nectarines

	PMA block				*Standard block*			
Stage	product	date	rate/acre	cost/acre	product	date	rate	cost/acre
DORMANT	Hort. Oil	01/29/00	6 gal.	$18	Hort. Oil	01/29/00	3 gal.	$9
					Asana	01/29/00	8 oz.	$16
					Lorsban 4E	01/29/00	2 qt.	$20
subtotal				***$18***				***$45***
BLOOM								
Subtotal				***$18***				***$45***
PETAL-FALL	Isomate ties	late-Mar	100 ties	$35	Carzol SP	03/17/00	1 lb.	$38
	Success	03/17/00	6 oz.	$29				
Subtotal				***$82***				***$83***
IN-SEASON	Success	05/21/00	6 oz.	$29	Success	05/21/00	6 oz.	$29
	Apollo	05/25/00	6 oz.	$68	Apollo	05/25/00	6 oz.	$68
Subtotal				***$179***				***$180***

Table 3.

Royal Glo nectarines

	PMA block				*Standard block*			
Stage	product	date	rate/acre	cost/acre	product	date	rate	cost/acre
DORMANT	Hort. Oil	01/29/00	6 gal.	$18	Hort. Oil	01/29/00	3 gal.	$9
					Asana	01/29/00	8 oz.	$16
					Lorsban 4E	01/29/00	2 qt.	$20
Subtotal				***$18***				***$45***
BLOOM	Mycotrol	03/17/00	6 oz.	$33	Carzol SP	03/17/00	1 lb.	$38
Subtotal				***$51***				***$83***
PETAL-FALL	Isomate ties	late-Mar	100 ties	$35				
Subtotal				***$86***				***$83***
IN-SEASON	Crymax Bt	05/16/00	1 lb.	$12	Crymax Bt	05/16/00	1 lb.	$12
	Lannate	05/24/00			Lannate	05/24/00		
Subtotal				***$98***				***$95***

Table 4.

Grand Rosa plums

	PMA block				*Standard block*			
stage	product	date	rate/acre	cost/acre	product	date	rate	cost/acre
DORMANT	Hort. Oil	01/29/00	6 gal.	$18	Hort. Oil	01/29/00	3 gal.	$9
					Asana	01/29/00	8 oz.	$16
					Lorsban 4E	01/29/00	2 qt.	$20
subtotal				***$18***				***$45***
BLOOM								
subtotal				***$18***				***$45***
PETAL-FALL	Isomate ties	late-Mar	100 ties	$35	Carzol SP	03/17/00	1 lb.	$38
	Success	03/17/00	6 oz.	$29				
								GR sprayed for thrips?
subtotal				***$82***				***$83***
IN-SEASON	Success	05/21/00	6 oz.	$29	Success	05/21/00	6 oz.	$29
subtotal				***$111***				***$112***

Table 5.

Red Jim nectarines

	PMA block				Standard block			
stage	product	date	rate/acre	cost/acre	product	date	rate	cost/acre
DORMANT	Hort. Oil	mid-Jan	8 gal.	$24	Hort. Oil	mid-Jan	3 gal.	$9
					Asana	mid-Jan	8 oz.	$16
					Diazinon	mid-Jan	3 lbs.	$15
subtotal				***$24***				***$40***
BLOOM	Success	03/17/00	6 oz.	$29	Carzol SP	03/17/00	1 lb.	$38
	Crymax Bt	03/17/00	1 lb.	$12	Crymax Bt	03/17/00	1 lb.	$12
subtotal				***$65***				***$90***
PETAL-FALL	Isomate ties	late-Mar	100 ties	$35	Crymax Bt	04/05/00	1 lb.	$12
	Crymax Bt	04/05/00	1 lb.	$12				
subtotal				***$112***				***$102***
IN-SEASON	Success	04/15/00	6 oz.	$29	Success	04/15/00	6 oz.	$29
	Success	05/04/00	6 oz.	$29	Imidan	05/04/00	4 lbs.	$26
					Apollo	05/04/00	3 oz.	$34
subtotal				***$170***				***$191***

Ave. PMA cost/acre: $128
Ave. CON cost/acre: $130